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Plotnikov N.I.

Psychological modeling of air traffic control communications in protection against mid-air collisions and near misses of aircraft in air navigation

Abstract: In this paper, mid-air collisions and near misses of aircraft are investigated in the aspect of communication between the flight crew and the air navigation service. A statistical review of the observations and the analysis reveals that the most important solution to blocking the danger are the parameters of the "air traffic controller - pilot" communication in the interaction of the crew and the service. It has been established that the essential parameters of the interaction between controllers and pilots are the structure, context and channels of voice communications, which have a much more complex structural content that is absent in modern standards. In practical terms, the work is aimed at developing collision protection recommendations by optimizing the standards of the regulatory framework.

Keywords: air navigation, collisions, near misses, aircraft, flight safety, air traffic controller, pilot, communications

Introduction

Mid-Air Collision (MAC) is an air accident (AA) in which two aircraft collide in flight. Air collisions almost always lead to two crashes of the colliding aircraft. Near misses (NM), airmisses, near collisions) are prerequisites for collisions: runway, on taxiing with parked aircraft, with obstacles on the ground - controlled flight into terrain (CFIT) of the world civil aviation (CA). The reasons for the MAC and NM are assessed not in favor of the aircraft crew in a ratio of 1:4 [1]. In this paper, MAC and NM events are investigated in the aspect of communications between the aircraft crew and the ATC service. A statistical review observation was performed. The analysis reveals that the most important solution to blocking the danger is the parameters of the "controller-pilot" communication in the interaction of the aircraft crew and the ATC service. It has been established that the essential parameters of interaction between air traffic controllers and pilots are the structure, context and channels of voice communications, which have a much more complex structural content that is absent in modern ATC standards. In practical terms, the work is aimed at developing recommendations for FS by optimizing the standards of the regulatory framework.

Problem Overview

The existing methods for calculating the MAC and NM are extremely complex. That is approximately considered as movement (NM) at distances (S) equal to or less than half the interval of the normalized flight level (FL) (1):

$$\mathrm{NM}\colon S_{\mathrm{NM}} \leq S_{\mathrm{FL}}/2. \quad (1)$$

The regulatory framework for the regulation of air traffic is dispersed in numerous documents and requires a clearer subject identification of terms and definitions. The connection between MAC and NM should be recognized as stochastic. The presented statistics are fragmentary, can be recognized as examples of accounting and do not allow for a full analysis of air traffic services (ATS). The general problem is the uncertainty as to how established and justified the relationship between the accident and the quality of communications "controller-pilot". Communication takes place on the audio channel. The controller can "self-confirm" visually by the locator, that is, "see what heard". Meanwhile, this very moment appears in the accident investigations, when the pilot misunderstood the instruction [2]. The most vulnerable points are the points of "blooper" (lapsus linguae) and "mishearing" messages. The biggest problem is the hear back problem [3, 4].

Method and Task

The method of resource modeling in this work is considered by the author as a scientific approach to the study of complex and weakly structured scientific problems, the solution of which by known theories and methods is not possible and is not achieved over long periods of time. The method is installed in the sequence of performing statistical analysis of events, information modeling. Due to the lack of acceptable mathematical methods, symbolic formalizations are used to formulate and solve the problem of this work [5]. The aim of the study is to find and establish new theoretical approaches to modeling events, suitable for calculation and computing. The operational reliability of the interaction requires modern technical means, depends on professional training, experience and operational WL. The safety conditions in the simplest form can be written as the ratio of the actual workload (AWL) and the normative workload (NWL) of pilot (P) and controller (C), corresponding to the standardized risks (2):

$$\begin{Bmatrix} \mathrm{AWL_P} \le \mathrm{NWL_P} \\ \mathrm{AWL_C} \le \mathrm{NWL_C} \end{Bmatrix} \le \mathrm{F}_{AA} \begin{Bmatrix} 1 \cdot 10^{-7} \frac{1}{\text{час}}, \mathrm{M}AC \\ 5 \cdot 10^{-4} \frac{1}{\text{час}}, \mathrm{NM} \end{Bmatrix}, \tag{2}$$

where F – function of solving the problem of blocking danger of AA.

Psychological Modeling of ATC Communications

This paper briefly examines the subject of message formation from the standpoint of the mathematical theory of communication, qualitative information theory [6, 7], psycholinguistics theory of communication [7]. The evaluation of these theories is carried out to establish the possibilities of their application. Communication channels in psychology are studied as ways of transmitting and receiving messages through the senses: A - auditory (hearing), V - visual (vision), K - kinesthetic (tactile). There is also a digital (discrete) channel, which is also considered part of the A-channel. The totality of the AVK-channels of an individual in the transmission and reception of messages forms the representative system (RS) of a person. If any channel in a person predominates in nature and experience, then this is called the leading system (LS). In psychology, it has been established that regardless of the LS, the communication channels of people differ in the completeness of the volume and the accuracy of the content. The most accurate in terms of content is the A-channel. The most complete in terms of volume is the K-channel. The simplest model for assessing the reliability of communications in this work is presented as follows (table 1).

Table 1 – AVK Communication model

	Communication		Reliability	
Channel	Transmitter	Receiver	Completeness	Accuracy
A	speaks	listens	minimum	high
B	shows	looks	average	average
К	moves	feels	high	minimum

Since each person's RS is unique, this leads to a fundamental obstacle - **the problem of understanding**. It has been established that there are ways to re-encode messages between channels. The receiver subject is able to recode, for example, an A-message into a B-message, or "see what was said." Just draw what you were told. Similar transcoding is possible between other channels. Let's compose a more complex communication model as a two-dimensional matrix. Since such developments are unknown in the studies known to the author, this model is presented as an original one, having a theoretical value and a basis for further research. Fragments of the model, which are pseudo-channels of communication, are italicized. For their interpretation, there is still not enough theoretical knowledge and experiments. The demonstration of this model shows that the "controller-pilot" communication standardized in modern technologies is carried out mainly according to one of all possible options (cell "AA" of the тable 2).

Table 2 – AVK Communication Matrix

Subjects → ↓		Receiving message		
		}В seen	}А heard	}К simulated
Transmitting message	В→ shown	}ВВ→ seen shown В→}В shown for vision	*}АВ→ heard shown В→}А shown to hear*	}КВ→ simulated shown В→}К shown for imitations
	А→ said	}ВА→ seen what said А→}В said for vision	**}АА→ heard what said А→}А said to hear**	}КА→ simulated what said А→}К said for imitation
	К→ movemen t	}ВК→ movement seen К→}В movemen t for vision	*}АК→ heard movement К→}А movement to hear*	}КК→ simulated movement К→}К movement for imitation

The solution to the problem is to find a way to include all theoretically identified channels to achieve reliable communications. However, even standard ATC communications have structural complexity that distorts messages and poses a threat to flight safety. An example of modelling is presented below.

Experimental Model of Distortion of Standard ATC Communications. Communication is carried out on the A-channel "speaking-listening". A call to communication can be carried out by the controller of the ATC and the crew of the aircraft. Let a standardized communication session (CS) contain communication procedures (CP), consisting of three pairs or six communication operations (CO). The six operations are called in this work the Operational Directive Loop (OPL) for ATC purposes. Other CP are called the ATC off-line circuit, for example, such as mutual informing of the controller and the crew about the meteorological conditions of the flight.

Demonstration of the failure of communication technology can occur in the following scenario. In the controller message 1A [b], the pilot misheard and repeats the numbers by mistake 1P [a]. The controller does not hear or listen to the content of 2P [v]. His attention is focused only on the very fact that his instruction is being repeated. The controller gives 3A [b] confirmation of the pilot's incorrect answer or does not give any confirmation. The communication chain generates distortion of each CO and the OPL collapses (3).

$$1\mathrm{C}[\text{в}] \stackrel{\text{def}}{=} \rightarrow \{1\mathrm{P}[\tilde{\text{а}}] \rightarrow 2\mathrm{P}[\tilde{\text{в}}] \ \rightarrow 3\mathrm{C}[\tilde{\text{в}} \rightarrow 3\mathrm{P}[\tilde{\text{а}}]\} \neq \stackrel{\text{def}}{=} 1\mathrm{A}[\text{в}]. \qquad (3)$$

The pilot in operation 3P [a] does not seek confirmation of the connection, since he has no doubts about the content of the air traffic control message 1C [b] (!). This excludes the last opportunity to correct a mistake, possibly tragic. These examples demonstrate many prerequisites for disruption of communications even in standardized ATC communications.

MAC and NM prevention task The event (E) of blocking the air traffic control system is defined as the formulation and solution of the problem of air navigation, flight operation in the "controller-pilot" communication. Air navigation (A), flight operation (P) and their parameters constitute a complex for performing a safe flight {A-P}. The observation base (M) and many of its manifestations are a methodological solver of the problem. The general condition of the problem is written (4):

$$\mathrm{MAC\ (NM)}: \begin{Bmatrix} M\{\mathrm{A.P}\} \rightarrow f(\mathrm{E} \quad), \text{the event occur} \\ M\{\mathrm{A.P}\} \ \rightarrow f'(\bar{\mathrm{E}} \quad), \text{the event does not occur} \end{Bmatrix}, \qquad (4)$$

where f and f' are functions of the initial and ultimate protection in solving the problem.

Let, for each $M_i \in M$ there is an environment $A_i \in A$ and conditions $P_i \in P$, when any event $E_i > 0$ in the phase space $\{E; \overline{E}\}$ is impossible if the function of the limit protection solver and hazard blocking $M_i \rightarrow \max f'$. Particular tasks for observation parameters can be formulated in a similar way. In accordance with the projected content of the subject area, observation tasks for objects in natural language (NL) are formed with a subsequent formalized description. Parameter names can be taken as object names, one of which is determined by the observation base.

Conclusion

This work has a search character with the aim of researching new, previously unexplored aspects of air navigation. It is postulated that air traffic controller-pilot communications are the main component of ATS safety management and MAC (NM) events prevention. Reliability of communications between the controller and the pilot is the resultant parameter of air traffic safety surveillance. The development and design of a flight safety complex was carried out, the identification of the main object: communications "controller-pilot" and threat events. The subject of the interaction between the pilot and the controller requires interdisciplinary research and development. Fundamental solutions may be the introduction of visual and kinesthetic channels into communication for communication through technological advances.

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Степанцов М.Е.

Об одной особенности моделирования первого этапа распространения инфекции COVID-19

Аннотация: В работе рассмотрен ход моделирования распространения инфекции на первом этапе пандемии, выявлены несоответствия между результатами моделирования при помощи непрерывных функций и на основе дискретных моделей класса клеточных автоматов. По результатам анализа этих несоответствий указано на возможную ошибку при использовании непрерывных моделей в данном случае и даны рекомендации по ее избеганию.

Ключевые слова: распространение инфекции, математическое моделирование, дискретные модели, клеточные автоматы

Безусловно, главной проблемой безопасности на данном этапе развития человечества стала пандемия новой коронавирусной инфекции и последствия как самого заболевания, так и ограничительных мер, призванных сдержать ее распространение. Математическое моделирование динамики этих процессов представляет собой не просто задачу с рядом неопределенных параметров – оно является задачей, в которой не определено, какие параметры и в какой степени являются неопределенными.

Так, в этот период постоянно менялись данные о различиях в характере распространения разных штаммов вируса, взятие анализов на наличие вируса в разных странах производилось у разных групп населения, использовались тесты разного качества с